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Radiation Dose Associated With Over Scanning in Neck CT

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A B S T R A C T

The increasing utilization of computed tomography scans exposes patients to significant amounts of radiation. One of the factors that can result in unnecessary radiation dose is scanning beyond the clinically indicated anatomical region. This study aims to assess the optimization in overscan frequency, scan length, and radiation dose following targeted educational talks aimed to address a routinely over scanned protocol; the computed tomography Neck. A targeted radiation awareness talk regarding scan adherence as a method of radiation dose optimization was delivered to all medical imaging technologists employed at a large teaching hospital. An audit of the radiation dose associated with computed tomography Neck protocols was conducted in the month before, a month after and 1 year after the awareness talk. Results show that following the radiation awareness talks there was a 15% reduction in overscan frequency, an average over scan length reduction of 33% and a 20% reduction in overall radiation dose. The targeted nature of the talk, explicitly addressing scan range in the neck region, significantly reduced radiation dose to the patients. The results of this study are effective in illustrating the potential clinical radiation dose saving from strict adherence to scan range.

Introduction

Computed tomography (CT) scans are becoming increasingly relevant to the primary diagnosis and staging of disease, and thus consideration must be given to radiation dose optimization in CT. Current literature on this topic identifies adherence to scan length in CT as being paramount to keeping radiation dose imparted as low as reasonably achievable.[1-3] For example, a recent phantom study has shown an increase in scan length of 6 cm on top of the prescribed scan region could result in an increase of 1 mSv of radiation dose.[4] Given the magnitude of CT scans performed worldwide, it is thus essential to investigate the incidence of overscan and contrast it with that presented in the literature. However, there is little exploration in the literature as to the clinical incidence and magnitude of overscan, as well as the increase in dose thus imparted to the patients.

The radiographer plays a significant role in selecting the appropriate scan region to comply with a particular imaging request. However, the radiographer must simultaneously aim to keep the radiation dose delivered as low as possible. It is up to the judgment of the radiographer to negotiate a comfortable medium between obtaining enough diagnostic information and keeping radiation dose to a minimum. Hence radiographer education is vital in raising awareness regarding radiation dose optimization through scan length control.

A typical body region that exhibits overscan at the authors' institution is the neck. Adherence to this protocol is low as reported by ongoing feedback through radiologist quality control. One obvious means of emphasizing the importance of protocol adherence would be to deliver targeted education talks to radiographers as to its significance. However, the delivery of such talks, their content, and their long-term value is a not a topic that is well covered in the literature. Furthermore, it is unknown whether such talks would have any significant ongoing effect on overall imparted dose in the long term.

The purpose of this study is to assess the impact of tailored educational talks, given at a large tertiary hospital in metropolitan Victoria, on the topic of scan length adherence, the length of overscan, and associated radiation dose. It is hoped that by doing so, evidence can be gathered as to the utility of such education and what factors can enhance the effects of radiation awareness amongst medical imaging technicians. The second aim of this study is to assess the incidence, length of overscan, and radiation dose in the preawareness period, to present data as to the extent of this issue at a large tertiary hospital.

Methods

Study Design

A retrospective study was performed to detect differences between scan protocol adherence before and after educational talks given to medical imaging technologists on the relationship between scan length and radiation dose. Data was collected from 3, 1 month phases: preradiation awareness educational talks, immediately post-radiation awareness educational talks, and 1 year after the radiation awareness educational talks. All neck CT cases within the designated 1 month period were included, unless the clinical question justified an increased or decreased scan coverage. Data collected included the length of overscan, radiation output (computed tomography dose

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index [CTDI] and Dose Length Product [DLP]), and patient demographics (age, the effective diameter of the neck, and gender).

A single imaging protocol was examined in this study, that being the neck CT. The neck region was chosen due to it being a region that is frequently over scanned at the authors' institution. Only clinical scans that were ordered requesting standard protocols were included. Any scans that required overscan for clinically justifiable reasons and all scans performed for research studies were excluded.

Study Setting

The hospital this study was conducted at has 4 CT scanners in 2 departments. Radiology department scanners are GE VCT, GE Revolution EVO, and Toshiba Aquilion Prime. The emergency department uses a GE Revolution EVO.

Areas of specialty at this hospital include Oncology, Orthopedic, General Angiography, as well as Acute Stroke Imaging, and Coronary Angiography. This is a teaching hospital and therefore employs a variety of skilled staff and interns. There are also numerous students that rotate through all scanners. In CT specifically, there are 45 radiographers that work throughout 4 scanners, so the accessibility to scanning protocols is crucial to ensure consistency between scanners and all staff. The educational talk given targeted these 45 radiographers specifically.

Raising Radiation Awareness

During departmental meetings, a radiation safety talk was delivered to radiographers scheduled to work in the radiology and emergency department CT. An experienced, qualified CT Supervisor was the staff member delivering the talk. The talks focused on the effect of scan length on patient dose and outlined the potential dose savings to patients through the use of careful planning of acquisitions. Following the departmental meetings, an email was sent to all CT staff summarizing the discussion to ensure all employees received the information. To ensure good practice was upheld following the radiation safety talks and the dissemination of the scanning protocols, a QA process was set up to allow feedback to radiographers performing the exams. The QA process continuously highlighted unjustified overscanned images to drive long term change of practice. This was achieved by utilizing the keyword functionality of the AGFA IMPAX system. Radiologists were able to flag a study that contains additional scan coverage allowing the CT supervisors to feed this information back to the radiographers and further educate them on possible dose savings.

Data Collection

The measurement of overscan was conducted using the markup calliper tool on AGFA Impax version 6.5.2.1528. The clinical scan region for neck at this institute was from inferior sphenoid sinus to the aortopulmonary window. A margin of 2 cm was deemed acceptable overscan by the radiologists, with anything beyond being categorized as nonadherence to the protocol (Fig 1). These measurements were conducted by an experienced CT supervisor. The measurements were checked by a second medical imaging technologist to ensure reliability. The CTDI and DLP, as well as patient information, were recorded from the radiation structured report in each patient file. The $CTDI_{vol}$ on all CT scanners was checked for accuracy in all phases of the study and was within 10%.

A measurement of the anterior-posterior and lateral dimensions of each patient's neck was conducted using the same methods above. These were obtained in the anterior-posterior plane between C4 and C5 disc. The Lateral measurement was obtained at the same level through the midvertebral body (Fig 2). The effective diameter of the neck was then calculated using the following equation:

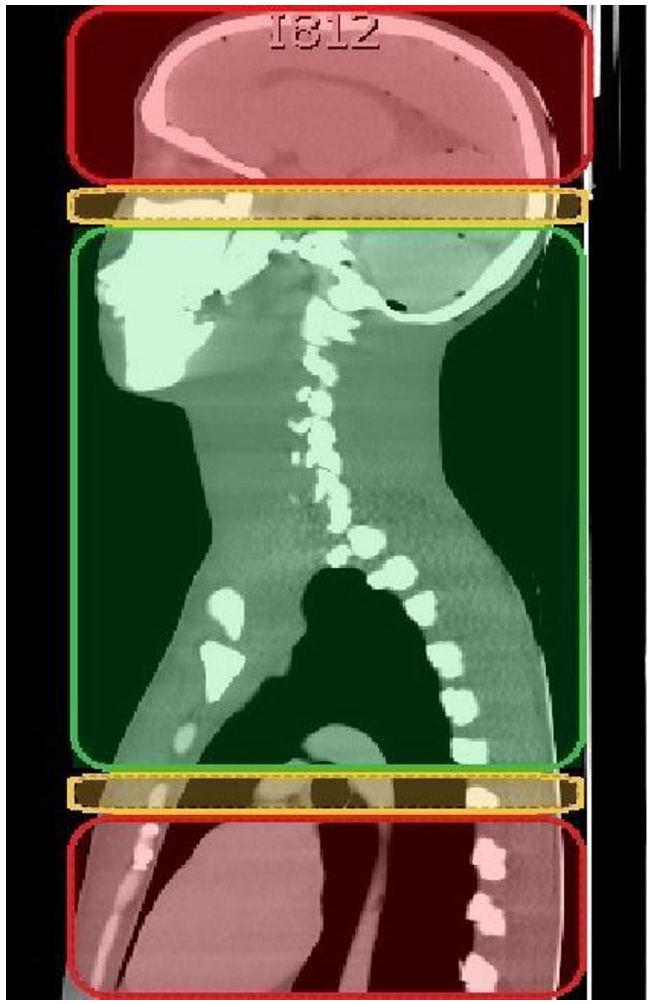

FIG 1. Scan regions for the Neck protocol at this establishment. Green denotes correct scan protocol. The yellow region is the acceptable margin of overscan. The red region is deemed to be unnecessary overscan for a routine neck protocol. (Color version of figure is available online.)

$$\text{effective diameter} = \sqrt{\text{AP} \times \text{LAT}}$$

The effective diameter was used to estimate the circular cross-section of the neck to allow comparison between patient groups within the different phases. This was done to lower falsely detecting a difference in dose that was attributable to patient demographics.

Radiation dose metrics used to monitor dose optimization were $CTDI_{vol}$ as a comparative measure in machine output and DLP to assess changes in radiation dose due to both machine output and scan length. The DLP was converted to effective dose by applying the k-factor of 0.0059 mSv mGy cm^{-1} for a neck scan in an average adult patient.[5]

Statistical Analysis

Data were retrospectively collected from the period 1 month before radiation awareness talks, immediately following, and 1 year after. The data that was collected included patient demographics, $CTDI_{vol}$, DLP, and the length scanned beyond the hospital protocol. A one-way ANOVA was used to detect statistical significance at $P < 0.05$ between the 3 phases of the study. A post hoc Tukey's multiple comparison tests were conducted when a statistically significant difference was found. A chi-squared test was used for the significance of categorical values to assess the difference in patient demographics

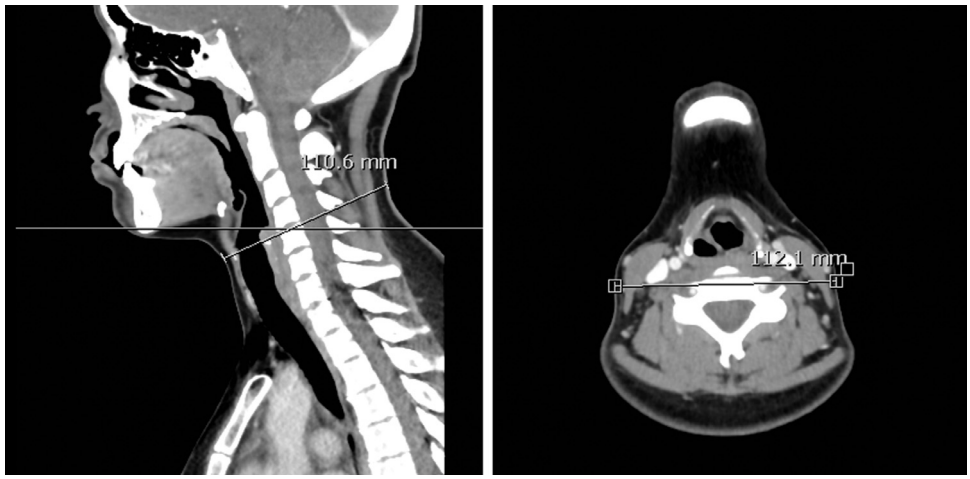

FIG 2. Location of the measurements of patient neck size. Anterior-posterior plane (left) were obtained through C4/C5 in the lateral plane (right) through the midvertebral body.

between the different phases. The data for continuous variables are presented as mean (standard deviation). The analysis was performed using R version 3.2.2.

Results

A total of 102 scans were included in this study, 31 in the preawareness phase and 41 one month postawareness, and 30 one year postawareness. The study characteristics of the protocols are summarised in Table 1.

There were no significant differences detected between the phases in the patient demographics ($P > 0.05$). Likewise, there were no significant differences in radiation dose output ($CTDI_{vol}$) from the scanner in the different phases ($P = 0.3$). The total radiation output (DLP) and effective dose for the Neck CT both showed a significant difference between the phases ($P = 0.03$). The mean DLP was 460, 392, and 374 mGy cm and mean effective dose was 2.7, 2.3, and 2.2 mSv. There was a significant reduction in overscan length in the phases following the radiation awareness educational talks ($P = 0.02$). Similarly, there was a significant decrease in the frequency of overscan ($P = 0.03$)

Discussion

Limiting the scan range reduces the amount of tissue exposed to ionising radiation. This is a straightforward and efficient method of reducing patient dose. Although this is well known, scan range adherence was found to be low at the authors' institution. Lack of adherence resulted in unnecessary radiation dose to the patient that provides no additional diagnostic information. The incidence of overscan could be exaggerated due to this hospital being a major teaching hospital within the region. There is a significant turnover of students as well as radiographer experience, which may have a role to play in the frequency of overscan.

The typical CTDI and DLP reported in the literature for the neck region is 19-44 mGy and 324-460 mGy cm respectively.[6-8] The values reported in this study are 16 mGy, 474 mGy cm and 14 mGy, 374 mGy cm in the preoverscan and postoverscan awareness phase, respectively. The scanner output parameters did not exhibit a significant change between the phases as can be seen in the CTDI (Fig 3) yet a statistically significant difference in DLP was observed (Fig 4). Thus, the reduction in total radiation exposure can be attributed to a decrease in scan length. The decrease in DLP was up to 20% following raising awareness. This resulted in an effective dose reduction of 20% down from 2.8-2.2 mSv.

Further, the dose reduction between the phases can also be attributed to the frequency of over scanned images. The frequency decreased from 58% in the preawareness phase to 33% and 27% in the postawareness phase. The continued decrease in frequency a year following the talks indicates that knowledge retention following the talks was high. Furthermore, raising awareness regarding the scan range in the neck region ensured that quality control process was more likely to detect overscan. Finally, when overscan was detected, on average it had significantly decreased in length (Fig 5).

TABLE 1
Procedural characteristics of the neck CT scans in the different phases

	Phase 1	Phase 2	Phase 3	*P* value
n	31	41	30	
Age, years	51 (19)	54 (17)	53 (18)	0.8
Neck effective diameter, cm	125 (15)	128 (18)	126 (16)	0.7
Gender, %Male	45%	59%	60%	0.4
$CTDI_{vol}$, mGy	16 (7)	16 (7)	14 (6)	0.3
DLP, mGy cm	474 (131)	392 (104)	374 (117)	0.03*
Effective dose, mSv	2.8 (0.8)	2.3 (0.7)	2.2 (0.9)	0.03*
Overscan length, mm	33 (19)	23 (15)	22 (15)	0.02*
Overscan frequency	58%	33%	27%	0.03*

*Denotes statistical significance.

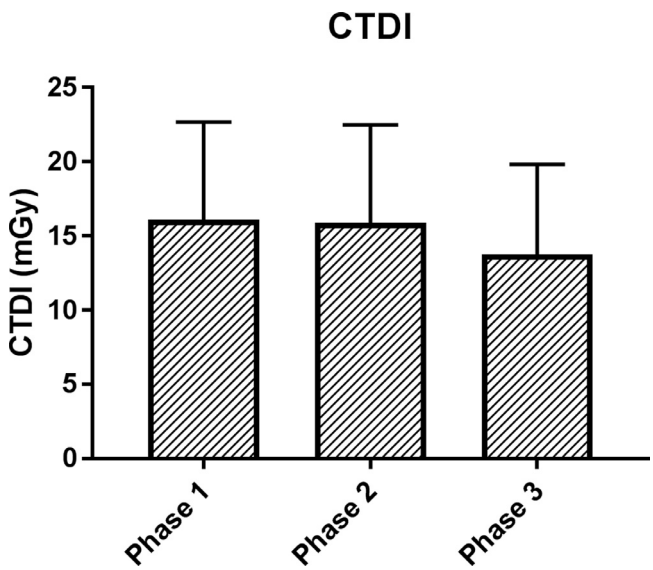

FIG 3. The CTDI in the varying phases of the study. The error bars represent the standard deviation.

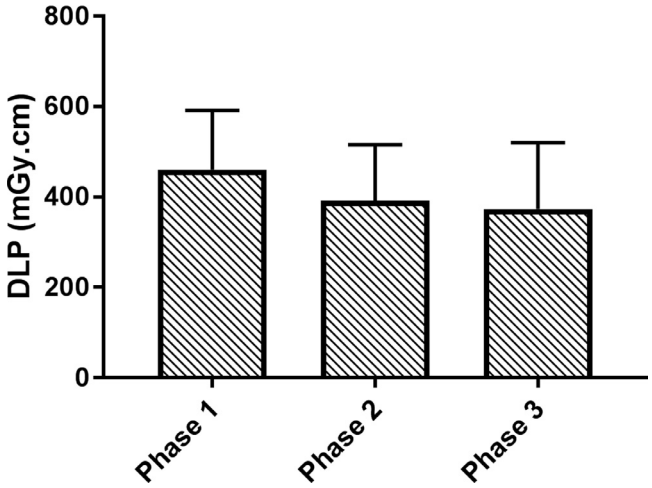

FIG 4. The Dose Length Product in the varying phases of the study. The error bars represent the standard deviation.

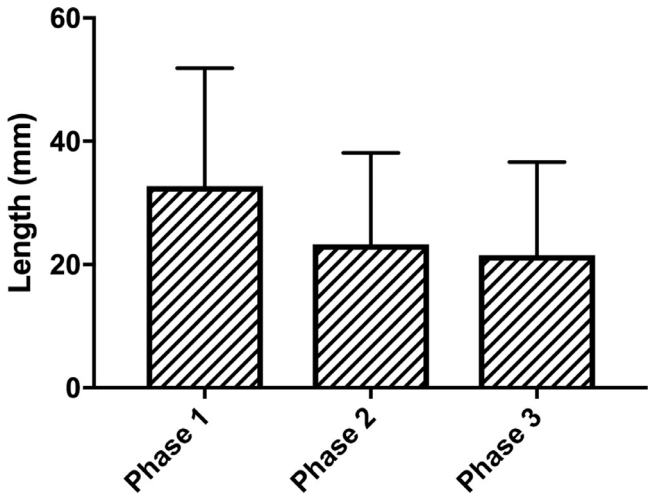

FIG 5. The length of overscan in the varying phases of the study. The error bars represent the standard deviation.

The Neck CT protocol was directly addressed at these meetings, and other scan regions may benefit from similar scrutiny. Further studies to establish the effects on other body regions are recommended. The authors suggest that targeted radiation talks can be an effective means of increasing knowledge retention and decreasing imparted dose in the long term. Educational talks should first comprise a survey of institution-specific protocol violations. Attention should then be given to raising targeted awareness with directed suggestions and examples. Furthermore, ongoing quality control will ensure that the effect is not only maintained directly after the talks, instead is continued in subsequent years.

Conclusion

The neck region was found to be routinely over scanned at a large tertiary institution. This resulted in a radiation dose of 2.8 mSv for a standard neck scan. Following a tailored radiation awareness talk and encouragement of quality control checks, the radiation dose was decreased to 2.2 mSv. Raising awareness regarding the increased radiation dose the patient is exposed to when an image is over scanned has shown to have a positive impact on radiation dose reduction in routine neck CT scans.

Ethics

This study underwent a human research ethics committee approval reference number LNR/16/Austin/307.

Conflict of Interest

The authors declare no conflict of interest.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.1067/j.cpradiol.2018.05.010.

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